the direction of the centrifugal force of the wave motion according to the generally received theory. This force is upwards at the crests, downwards in the hollows, and horizontal midway between the crests and hollows. If the weighted arm is compelled to assume successive angular positions, so that it is always at right angles to the force, it is evident that the force will be continually acting to cause the arm to rotate. It is easy to see how the work is taken out of the waves, for when the vessel is descending, the weight is performing the upper half of its revolution, and is consequently exerting an upward centrifugal force; and when the vessel is ascending, the centrifugal force is pushing down and resisting the vessel's ascent, so that the revolving weight affords a resistance against which the vessel can push just as if it were a fixed point in space. The shaft of the revolving weight can be made to turn a screw in the stern of the vessel by means of a proper system of gearing, and by a delicate arrangement of electric brakes and hydraulic accumulators, Mr. Tower proposes to regulate the revolving arm so as always to keep it at right angles to the centrifugal force of the waves.

THE FARADAY LECTURE

LAST Thursday, as our readers know, Dr. A. W. Hofmann, of Berlin, delivered at the Royal Institution the Faraday Lecture of the Chemical Society, his subject being "Liebig's Contributions to Experimental Chemistry." The audience included the Prince of Wales. Dr. Odling occupied the chair. The dinner on Friday at Willis's Rooms was probably one of the most remarkable scientific dinners that have taken place for some years, there being about 180 present, nearly all of them well-known men of science. Dr. Hofmann made a noble appeal on behalf of the recognition of the high value of pure scientific research; and Prof. Huxley acknowledged that while in scientific ideas we might be abreast of the Germans, yet the latter undoubtedly excelled us in the amount of their scientific work.

Dr. Hofmann in his lecture began by pointing out that Faraday belonged by the universality of his genius to all civilised countries, and the council of the Chemical Society had ordained that all countries should be asked to join in rendering homage to the greatest experimental thinker among mankind. On the present occasion Germany had been invited to take part in this international tribute, and it was a great honour for him to interpret his country's homage. His illustrious teacher and lamented friend Justus von Liebig was a master mind like Faraday, and Liebig's is the name and figure alone fitted to stand on equal terms beside Faraday. But to speak of Liebig only we must proclaim him one of the greatest contributors to chemistry at large, while of organic chemistry he was the founder. It is not only by the discovery of new facts that he was distinguished, but by the conception of general laws which illustrate both organic and inorganic chemistry. By the great types of composition which under the name of "radicles" he first spoke of, and by the researches to which these led, he guided not only his contemporaries, but will guide succeeding ages. He was also the first to found in Europe the great system of practical education. It was at Giessen he organised the first great laboratory of experimental instruction; and if we now admire magnificent temples of science, let us not forget that we owe them to him as their originator. He called around him distinguished students, many of whom were raised now to exalted positions by their talents and learning, and many of whom the lecturer saw before him; they would not be wanting in the tribute of heartfelt reverence to their great master. By his keen insight into chemical analogy he marked out the way of chemical research, and he also showed how to keep up the supply of human hearts and minds to prosecute his work. He provided arms, and soldiers to wield them.

There is no greater proof of the fecundity of genius than that it enriches the storehouse of science with its discoveries, and at the same time provides the means of ulterior conquest in ages yet to come. Which of us returning to-morrow to his lonely post in the laboratory could not feel cheered by the example of such men as Liebig and Faraday? It was the habit of Liebig to trace laws in their furthest results, and their applicability to promoting the practical welfare of mankind. No one has in this way more enriched us. Liebig's labours in abstract science bore fruit in the useful arts. He materially elucidated great industries, the manufacture of fulminating compounds and prussiate of potash, for instance, together with materials of the most important use in the manufacture of the precious metals, and silver-coated mirrors, so preferable for purposes of science and adornment to the old mercury-backed glasses. *Illustrans commoda vitae*, he never let slip any occasion of promoting the good of his fellow-creatures. His penetrating philosophy could not remain a stranger to the profound secrets of life based upon chemical change. He revealed the dependence of plants upon the chemical composition of the soil and air. He studied also the laws of nutrition and development of the animal body. In the former of these branches he was crowned with the greatest success. He began in 1840 by his work on agriculture and zoology, written in compliance with the request of the British Association at their 1837 meeting at Liverpool, and he followed it up by his work on husbandry. His labours resulted in the establishment of the philosophy of agriculture, and ranked him with Lavoisier, who showed in the last century how the vegetable stands between the mineral and the animal, and collects from the former world food for the latter. Lavoisier was followed by Humphry Davy, and after him came Liebig. They are the three great lawgivers of modern agriculture.

It was in 1842 that Liebig, passing onward from food-producers to animals, brought out his work on the subject, and it may be taken as a result of his work that the superabundant animal food of thinly-peopled parts of the earth has been, by a fast developing industry, brought over to guard Europe against the pinch of want. Those who are engaged in the curative art must bear him gratitude for the discovery of chloroform; nor will they forget chloral, the benign influences of which will even induce sleep, and rank it among the most sublime agencies placed at the disposal of therapeutics by chemical art.

He had, the lecturer said, selected but a few illustrations, which would give them a better idea than any long explanations by him of Liebig's voluminous life-work, and he asked them to accompany him in a rapid view of Liebig's memorable contributions to chemistry proper. But Liebig's contributions to the Royal Society's library were, in 1863, 317 in number, and 283 were entirely by himself. When the lecturer's pupils in Berlin heard that he had been entrusted with this lecture, they produced all the substances which Liebig at any period of his career more particularly illustrated; these preparations now crowded the table.

The first achievement he would allude to was that which, whether or not his most brilliant discovery, contributed most to facilitate the labours of chemists, and was the main source of the marvellous development of organic chemistry—analysis by combustion of organic bodies and the determination of their carbon by his form of measurement. Not one there but had determined the molecular weight of bodies, but they might not be aware that we are indebted for the process to Liebig. He never published any particular paper on the subject, but merely communicated his method in a paper on another chemist's researches. Its merit is simplicity, like that of his air analysis. That an alkaline solution of pyrogenic acid

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takes up oxygen and becomes more and more blackened by its action had long been known. But it was reserved for Liebig to found on the fact the measurement of oxygen. By treating the gas to be examined first with potash and then with pyrogenic acid, he combined the investigation for oxygen with that of carbonic acid.

Passing to the researches he effected by the instrumentality of his inventions, there came the fulminating compounds. At a remote period Liebig compared fulminic with picric acid. There was no satisfactory analysis of the method of fusing substances with prussiate of potash, and he first showed how iron is taken up by ferrocyanides, and his experiments are the foundation of the modern manufacture. Another valuable point was his simple process of obtaining cyanide of potassium. It is now manufactured on a large scale on his process, and is thus extensively used in electrotyping. This discovery led him to others. Liebig and Wöhler furnish us with the group of aromatic compounds which stream forth from benzol in infinite variety. At the conclusion of the description of their experiments they say their inquiries arrange themselves round a group of acids. This analogy induced them to consider the group as a kind of compound element, to which they gave the name of benzol.

When a chemist is fortunate enough to encounter some such guide in the midst of unknown nature, he has good cause to congratulate himself. If even now after forty years the results of this research have such fascination, what were the feelings of contemporaries? One of them "discerns the dawn of a new day," and suggests orthrine for the name of the new compound element from *ὄρθρος*, "day-break." Now, the lecturer should by rights unfold before their eyes the chain from oil of almonds to benzolic acid. But time reminded him to hasten on. The uric acid group furnished a path which had not yet conducted us to the goal. Uric acid was not all unknown in 1834, when Liebig established its formula. It had been known in 1734, but it was not till 1850 that a youth in his 19th year discovered the most fertile source of the compound. Liebig and Wöhler soon showed that its mutability, its liability to chemical change, entitled them to reap rich harvests from it. Sixteen new and most remarkable bodies were at a single stroke incorporated into the history of chemistry. Only one has since disappeared and called for rectification, and no better proof could be given of their scrupulous accuracy. They showed how clearly they discerned the synthetic direction which organic chemistry was about to take. Sugar, silicine, morphine would be, they say, synthetically prepared. One more illustration must suffice—the remarkable results in the investigation of alcohol. His first experiments were in 1832, when his inquiry, undertaken for purely scientific and abstract ends, led to the discovery of chloral and chloroform. He discovered hydrate of chloral and its beautiful crystalline form. In 1847, fifteen years after its discovery, chloroform was used for the first time as an anæsthetic, and twenty years more elapsed before Liebreich found a similar use for chloral. At the present day the chemical factories of Berlin alone produce 100 kilos. a day of the principal anæsthetic.

Liebig denied the presence of the olefiant gas previously ascribed to alcohols, and gave their chief constituent the name of ether, and although according to our present view the relation between alcohol and ether has changed, no one now speaks of the olefiant theory. The new system of chemical notation introduced by two French chemists was nowhere earlier championed than here, and by Faraday. To that England owes the honour of being foremost to recognise the truth of the new doctrine. Its modification of Liebig's formulæ extends also to his ether. Williamson elucidated the question with striking success, but Williamson owed to Liebig the very agents he so successfully employed. Liebig "had no doubt we should succeed in the analysis of ether." Liebig's dream was realised by Frankland.

Our respect and our admiration are due to Liebig not for his scientific labour alone: we learn from him that anxiety to discover abstract laws is not to be dissociated from efforts for the well-being of our race. The lecturer remembered a little incident so illustrative of Liebig's goodness of heart that he ventured to relate it. He then told the story of a broken soldier, whom, during a tour in the Tyrol, Liebig not only helped with florins, but procured quinine for by a toilsome walk over mountains. Of Faraday's kindness he had a touching example. A gentleman had handed him a letter of 1834, in which Faraday wrote to a student who had engaged, like many others, in a dream about matter and atoms, and was anxious to submit his ramblings in philosophic dreamland to the greatest chemist of the day. He forwarded it with the suggestion that it was worth while to test it. Overwhelmed, as Faraday then was, with work, he answered not with neglect or with cheap flattery; he wrote to the unknown youth as follows:—

"I have no hesitation in advising you to experiment in support of your views, because, whether you confirm or confute them, good must come out of your experiments. With regard to the views themselves, I can say nothing of them except that they are useful in exciting the mind to inquiry. A very brief consideration of the progress of experimental philosophy will show you that it is a great disturber of preconceived theories. I have thought long and closely on the theories of attraction and of particles and atoms of matter, and the more I think, in association with experiments, the less distinct does my idea of an atom or a particle of matter become."

In whatever epoch, continued the lecturer, we shall seek for models of human existence, we can find no two examples more conspicuous for their intellectual worth, more admirable for their lofty views of duty, than Michael Faraday and Justus von Liebig.

NOTES

THE *Enterprise*, with the eclipse party for Camorta (Nicobar Islands), left Galle on the 18th inst. The *Baroda* with the Siam party should arrive at Singapore to-day, and a telegram has been received at the Admiralty that the Colonial steamer will replace the *Charybdis* in the journey to Bangkok, as the former is faster and possesses more accommodation. Letters have been received from the expedition at Aden. Drs. Vogel and Schuster have been engaged on board in photographically determining the chemical intensity of different parts of the solar spectrum at different times of the day, and most important results have already been secured.

HER Majesty the Queen has been graciously pleased to confer upon Mr. Henry Cole, C.B., the distinction of a Commandership of the Bath, in recognition of his eminent public services. The Executive Committee of the Cole Testimonial Fund have authorised the preparation of a decorative memorial tablet, with portrait of Mr. Cole in mosaic, as well as a marble bust. It is intended to offer these to public institutions, and the balance of the amount subscribed will be placed at the disposal of Mr. Cole.

THE Royal Irish Academy has given its sanction to the following grants from the fund placed at its disposal for aiding scientific researches by providing suitable instruments and materials:—25*l*. to Mr. Edward T. Hardman, for "Chemico-Geological Researches;" 30*l*. to Mr. W. H. Mackintosh, for "Researches as to the Structure of the Echinoidea;" 25*l*. to Mr. G. Porte, for "Micro-Photographic Experiments;" 40*l*. to Dr. Leith Adams, for "Explorations in the Caves of Shandon;"

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